E7.3-11.110
NASA-CR-135579

Interim Report

ORSER-SSEL Technical Report 16-73

SURVEY AND INVENTORY OF FOREST RESOURCES

B. J. Turner and D. L. Williams

ERTS Investigation 082
Contract Number NAS 5-23133

INTERDISCIPLINARY APPLICATION AND INTERPRETATION OF ERTS DATA WITHIN THE SUSQUEHANNA RIVER BASIN

Resource Inventory, Land Use, and Pollution

Office for Remote Sensing of Earth Resources (ORSER)
Space Science and Engineering Laboratory (SSEL)
Room 219 Electrical Engineering West
The Pennsylvania State University
University Park, Pennsylvania 16802

(E73-11110) SURVEY AND INVENTORY OF FOREST RESOURCES Interim Report (Pennsylvania State Univ.) 14 p HC $3.00 CSCL 02F

N73-33267

Unclas
G3/13 01110

Principal Investigators:

Dr. George J. McMurtry
Dr. Gary W. Petersen

Date: May 1973

SURVEY AND INVENTORY OF FOREST RESOURCES

B. J. Turner and D. L. Williams

Before it is possible to determine the role of ERTS-1 data in a forest resources inventory, it is necessary to explore the limits of these data for discriminating vegetative differences. When these limits are known, progress toward the development of multi-stage sampling designs, detection of insect defoliation, etc., can be rapidly made. Results to date are encouraging. Computer processing of MSS tapes is yielding far more information than appeared possible from visual examination of ERTS imagery. However, there are some difficulties to be overcome before this preliminary phase of study can be considered satisfactorily completed.

Purpose and Scope

The initial goal of this project was to determine the extent to which it is possible to discriminate between coniferous and non-coniferous forest vegetation using ERTS-1 data, under typical Pennsylvania conditions of intimate mixtures of these two vegetative types. It was anticipated that this would lead to further exploration and problem definition.

The test area chosen, shown on the U2 photograph in Figure 1 , is a part of The Pennsylvania State University Experimental Forest in Stone Valley, Huntingdon County. This area includes the 70 acre University dam and the surrounding forest land, comprising approximately 4500 acres. This particular area was chosen for the following major reasons:

1. the vast amount of ground truth information available from previous vegetation studies on this area, carried out by various University groups;

2. the availability of adequate coniferous vegetation, both natural and planted;

3. the presence of a large area of uniform reflectance (the University dam) as a geographical reference point; and

PRINT NOT YET AVAILABLE

Figure 1: Enlargement of U2 photograph of the Stone Valley area. (Flight 73-009, sensor 12, frame 126; approximate scale:

4. the proximity of the area (about 12 miles) to the campus, facilitating ground checking.

Data Sources

Data from two ERTS-1 overpasses were used to give representative summer and winter conditions. These were:

1. Date: September 6, 1972
   Scene number: 1045-15243
   Tape number: #2 of 4
   Quality: Relatively cloud-free over test area
   Channels: Initially all 4, but channel 6 gave bad data in every sixth scan line and was not used in most of the analysis

2. Date: January 10, 1973
   Scene number: 1171-15245
   Tape number: #2 of 4
   Quality: Cloud-free, overall low reflectance
   Channels: All 4

Principal underflight support photography came from two U2 70 mm films. These were:

1. Date: June 7, 1972
   Flight number: 72-094
   Flight line: U-V
   Frame numbers: 172-173
   Sensors: 11 through 15
   Quality: Very good over test area

2. Date: January 25, 1973
   Flight number: 73-009
   Flight line: M-N
   Frame numbers: 126-127
   Sensors: 11 through 13
   Quality: Very good over test area

Photography from two small aircraft flights, privately flown for the Recreation and Parks Department of The Pennsylvania State University, were also used. These were flown on April 21 and May 10, 1972, and provided stereo coverage at a scale of 1:3000 and 1:12,000, respectively. Two maps were used: the USGS 7 1/2 minute quadrangle map of Pine Grove Mills, derived from 1962 photography; and a map of vegetative cover types of The Pennsylvania State University Experimental Forest, produced in 1965 (from 1962 photography) by the Pennsylvania Cooperative Wildlife Research Unit of the U.S. Department of the Interior.

Analytical Procedure

Separate work tapes were prepared, using the SUBSET program[1], from data from the September and January ERTS scenes for an area encompassing the test site. The first stage of analysis was concerned with locating geographical reference points, using the program NMAP. It became immediately apparent from the NMAP printouts that a channel of bad data was causing misrepresentation. Every sixth scan line of the printout consisted of sporadic data. This problem was "corrected" by eliminating all data from channel 6, and working only with channels 4, 5, and 7. This permitted use of data from the September scene, one of the few clear passes over the test area, but created at least two problems. First of all, the channel eliminated was the one containing the most information on vegetative cover. And secondly, because vegetation is such a dominating feature in summer imagery, elimination of the bad channel caused considerable changes in the overall reflectance values. As a result, the reflectance class limits for NMAP had to be recalculated to get satisfactory map output.

After these adjustments were made, NMAP printouts of the September and January scenes were compared. The low reflectance of the University dam in the summer scene permitted easy identification of this body of water, simplifying orientation within the test area. The dam was partially frozen over and snow covered in the January scene, and resembled the surrounding snow-covered land surface. This was confirmed from

---

[1] See ORSER-SSEL Technical Report 10-73 for complete program descriptions.

examination of the U2 imagery. For this scene, therefore, ridge shadow patterns were used, and compared with those of the September scene, for locational purposes.

The second stage of analysis was concerned with obtaining spectral signatures for gross vegetation cover types. The class limit adjustments made on the NMAP program for the September scene had resulted in such excellent definition of features that the intermediate steps of STATS and ACLASS were unnecessary, and the DCLUS program was run directly. This program maps a given area, assigns specific symbols to areas having the same spectral signatures, and calculates the spectral signatures for each symbol. The quality of the output can be enhanced by varying the critical angles or distances, and the sample size. These techniques were used until satisfactory results were obtained. The vegetation map of the Experimental Forest was used to identify the gross patterns of specific symbols on the map. A close resemblance of gross features was easily noticed, especially for pine plantations and the dam. For the January scene, a map obtained by DCLUS was used to define training areas for the STATS program, to check on the uniformity of these areas, and to compare STATS signatures and DCLUS signatures. These signatures were then combined as inputs to ACLASS and DCLASS runs, producing maps that discriminated the following targets: conifers, hardwoods, and shaded hardwoods. This map is shown in Figure 2; the categories, symbols used, and other information relevant to this map are shown in Table 1. The RATIO program was used with both scenes, to discriminate between conifers and non-conifers, using a ratio of channel 4 to channel 7 and using

Table 1: Category Statistics for the ACLASS Map Shown in Figure 2

Category Name	Number	Symbol	Limit	Count	Percent
CONIFERS	1	(P)	10.0	842.	20.
SHADE	2	(S)	10.0	1266.	31.
HARDWOODS	3	(H)	10.0	828.	20.
SNOW	4	(X)	10.0	1.	0.
OTHER	5	( )	0.0	1204.	29.
		TOTAL COUNT		4141.	

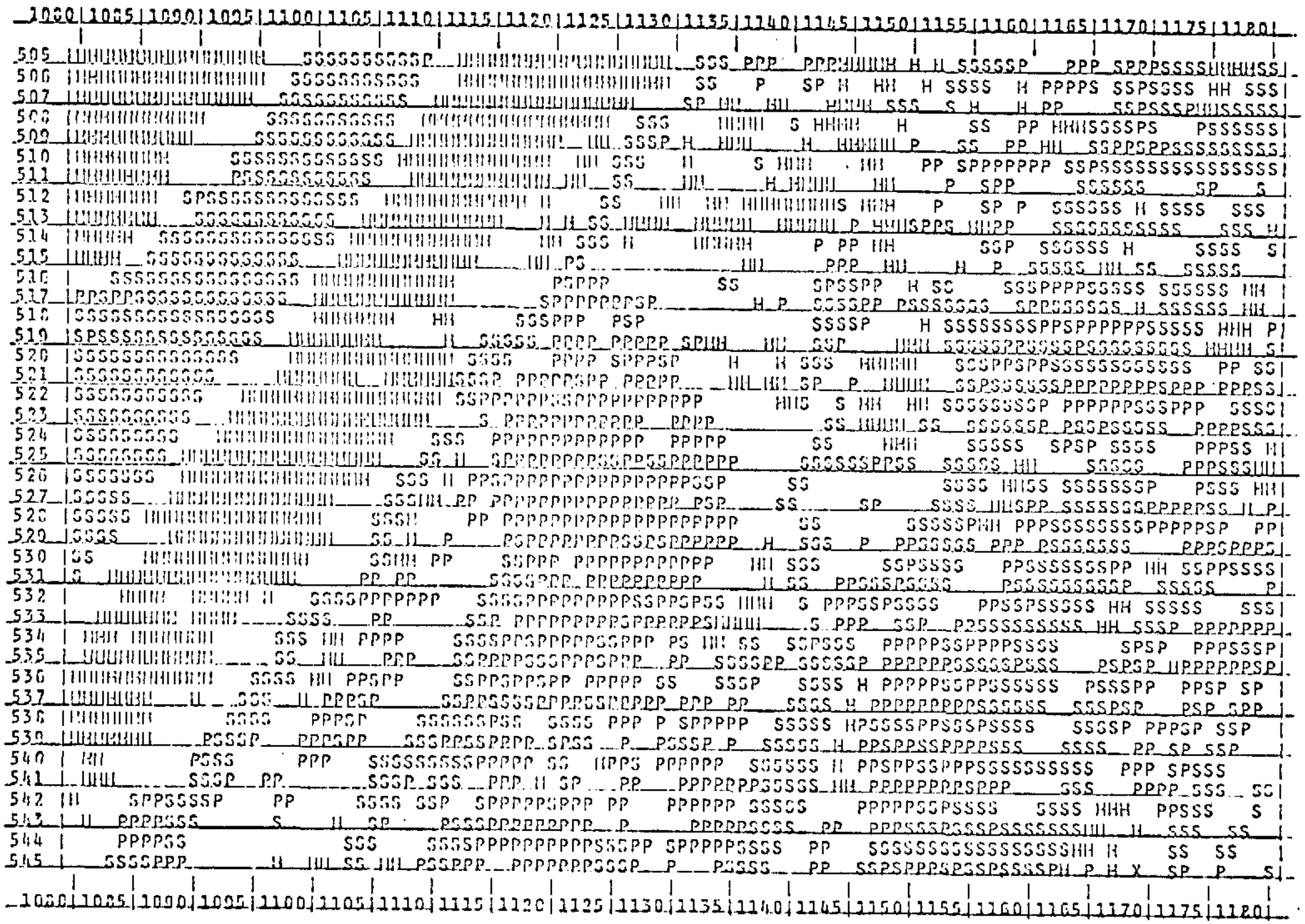

Figure 2 : ACLASS map of the January scene. This map is a product of STATS signatures developed from training areas defined on DCLUS output. (The symbols are defined in Table .)

information derived from the DCLUS program to set the discriminating ratio. The results from the RATIO program for the September scene are shown in Figure 3.

The third stage of analysis was concerned with using the combined data from both scenes, yielding seven channels of information, to refine the vegetational mapping. Before this could be done, however, it was necessary to locate precisely a geographic area common to both scenes. This was done by assigning a single category symbol, for pine plantations, to the January ACLASS and the September RATIO maps. These two maps were then superimposed on a light-table and the symbol areas matched as closely as possible. It was determined that the September 6 scene differed from that of January 10 by +68 scan lines and +81 elements. Data from the two scenes were then subset together onto a working tape, using the program MERGE. The UMAP program was used on this seven-channel data to locate training areas for the STATS program, which produced signatures which were then input to the ACLASS program. After some experimentation with critical angles, a satisfactory map, shown in Figure 4, was produced with ACLASS. The following vegetation types were defined: hardwoods, shaded hardwoods, hemlock hardwoods, conifers, fields, and water. Symbols and statistics for these categories are shown in Table 2.

Table 2: Category Statistics for the ACLASS Map of Merged Data Shown in Figure 4.

Category Name	Number	Symbol	Limit	Count	Percent
HARDWOODS	1	(*)	8.0	362.	9.
SHADED HARDWOODS	2	(S)	8.0	331.	8.
HARDWOODS	3	(*)	8.0	377.	9.
HARDWOODS	4	(*)	8.0	473.	11.
HARDWOODS	5	(*)	8.0	826.	20.
HEMLOCK-HARDWOODS	6	(=)	7.0	469.	11.
CONIFERS	7	(P)	7.0	538.	13.
WATER	8	(+)	13.0	58.	1.
FIELDS	9	(|)	8.0	556.	13.
OTHER	10	( )	0.0	151.	4.
			TOTAL COUNT	4141.	

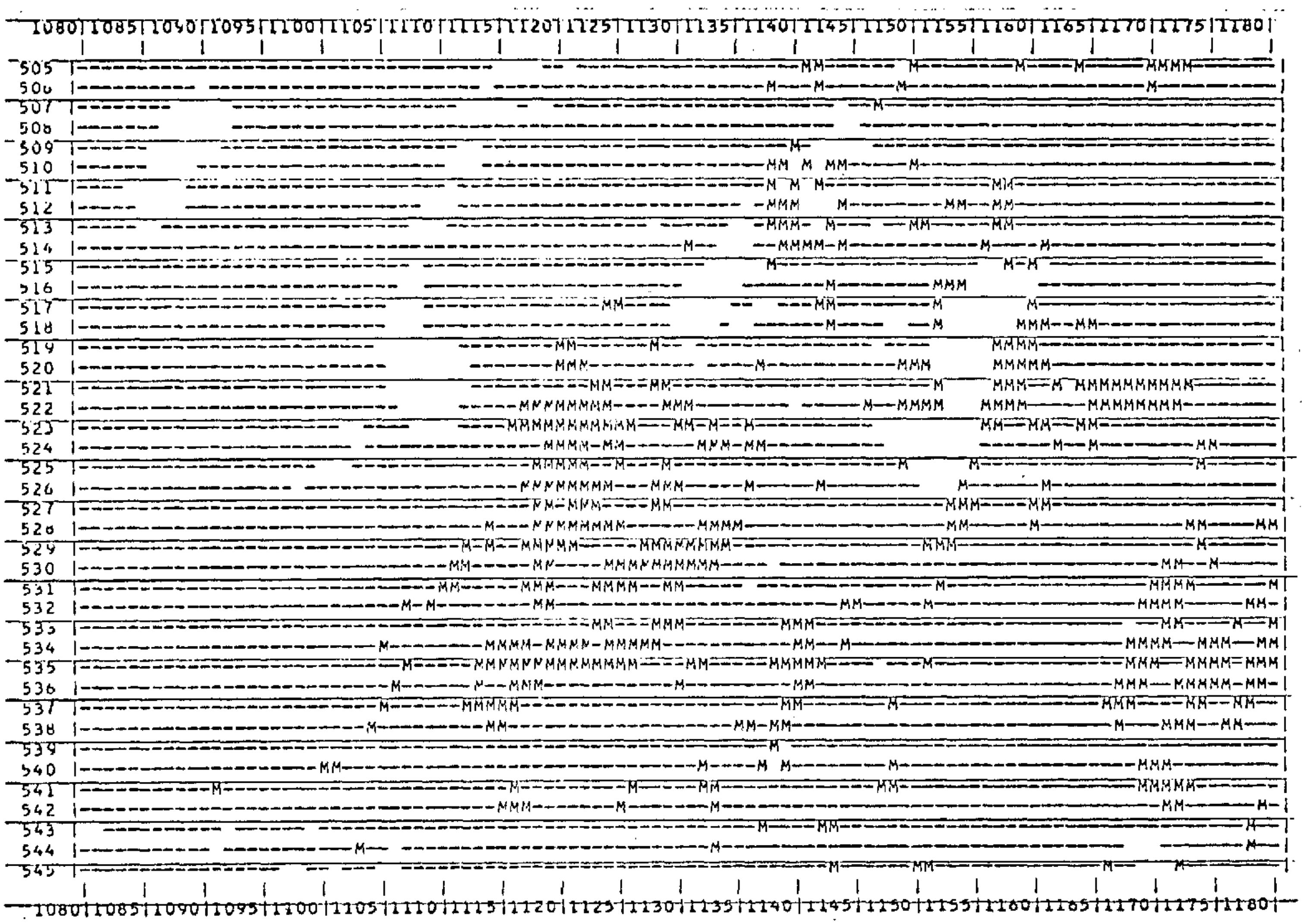

Figure 3 : RATIO map of the September scene. A ratio of channel 4 to channel 7 was used, with information derived from the DCLUS program used to set the discriminating ratio. Conifers are mapped with M's, all other classified vegetation with -'s; unclassified elements are blank.

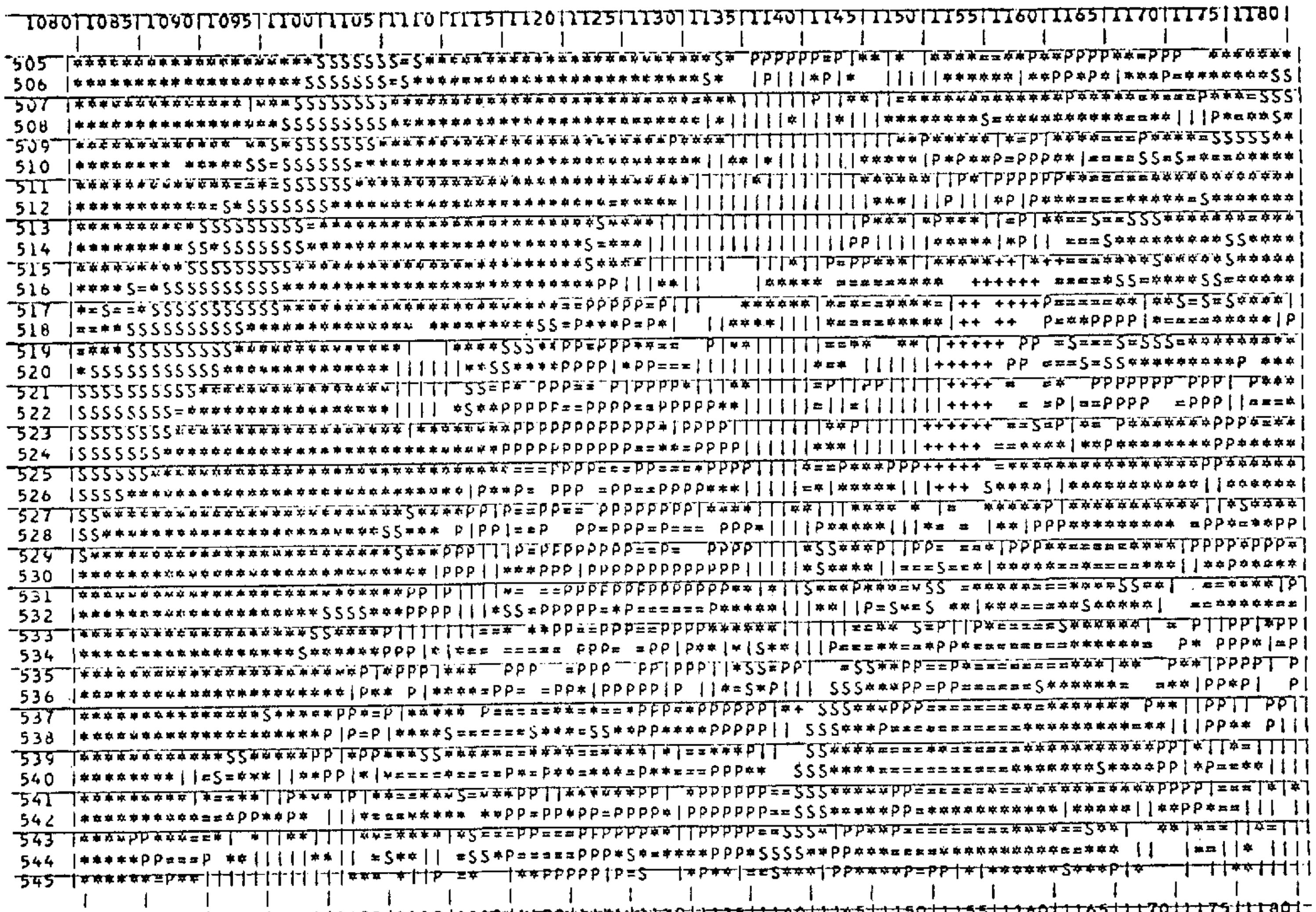

Figure 4 : ACLASS map resulting from merging the September and January scenes. (The symbols are defined in Table .)

Ground truth, in the form of maps, underflight photography, and a visit to the field area, was used to check the final map produced by the ACLASS program from the merged data. The USGS 7 1/2 minute topographic map was practically the same scale as the digital printout, facilitating the transfer of stream systems and roads to an overlay on the computer map. This map was then compared to the U2 and large-scale underflight photography, and to the vegetation map of the experimental forest. A half-day field inspection of the test area further refined the comparison with ground truth.

Results

Comparison of the vegetation map (Figure 5) with an LMAP printout of the ACLASS map from the merged data (Figure 6) indicates the accuracy that has been achieved in mapping vegetation classes in the test area by this method. The following results from this study have been realized:

1. Three ORSER programs (RATIO, ACLASS, and DCLUS) were able to isolate and map coniferous forest vegetation provided the conifers occurred in blocks of approximately five acres or more and comprised the bulk of the vegetation in those blocks. This was verified by ground truth, and was achieved on both summer and winter scenes.

2. The merging of winter and summer scene data made it possible to differentiate hardwoods with coniferous understory from hardwoods on the one hand and conifers on the other. This possibly was suggested when it was observed that conifers occurred in some areas in the winter scene maps which had been classified as hardwoods in the summer scenes. This area of apparent confusion was verified, by field-checking, as being hardwoods with an understory of hemlocks.

3. Discrimination between coniferous species on the basis of spectral characteristics alone does not appear very promising. However, where a particular species is associated with another vegetation type, discrimination is possible. Thus, hemlocks with hardwoods can be differentiated from coniferous plantations, and it seems likely that Virginia pine and table mountain pine on old fields can be also defined as a

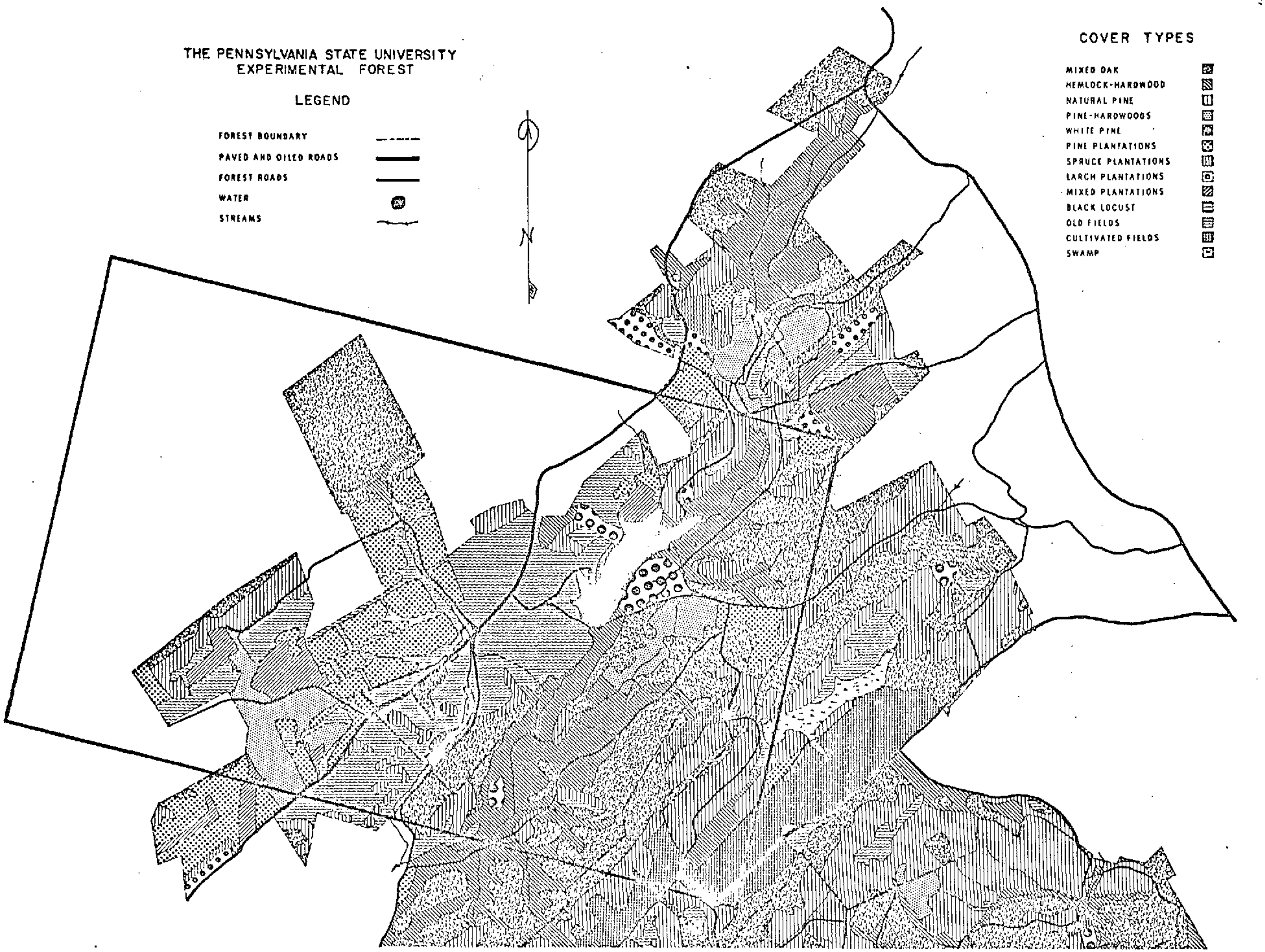

Figure 5: A portion of the vegetation map, indicating the test area. (Map produced in 1965 from 1962 photography, by the Pennsylvania Wildlife Research Unit.

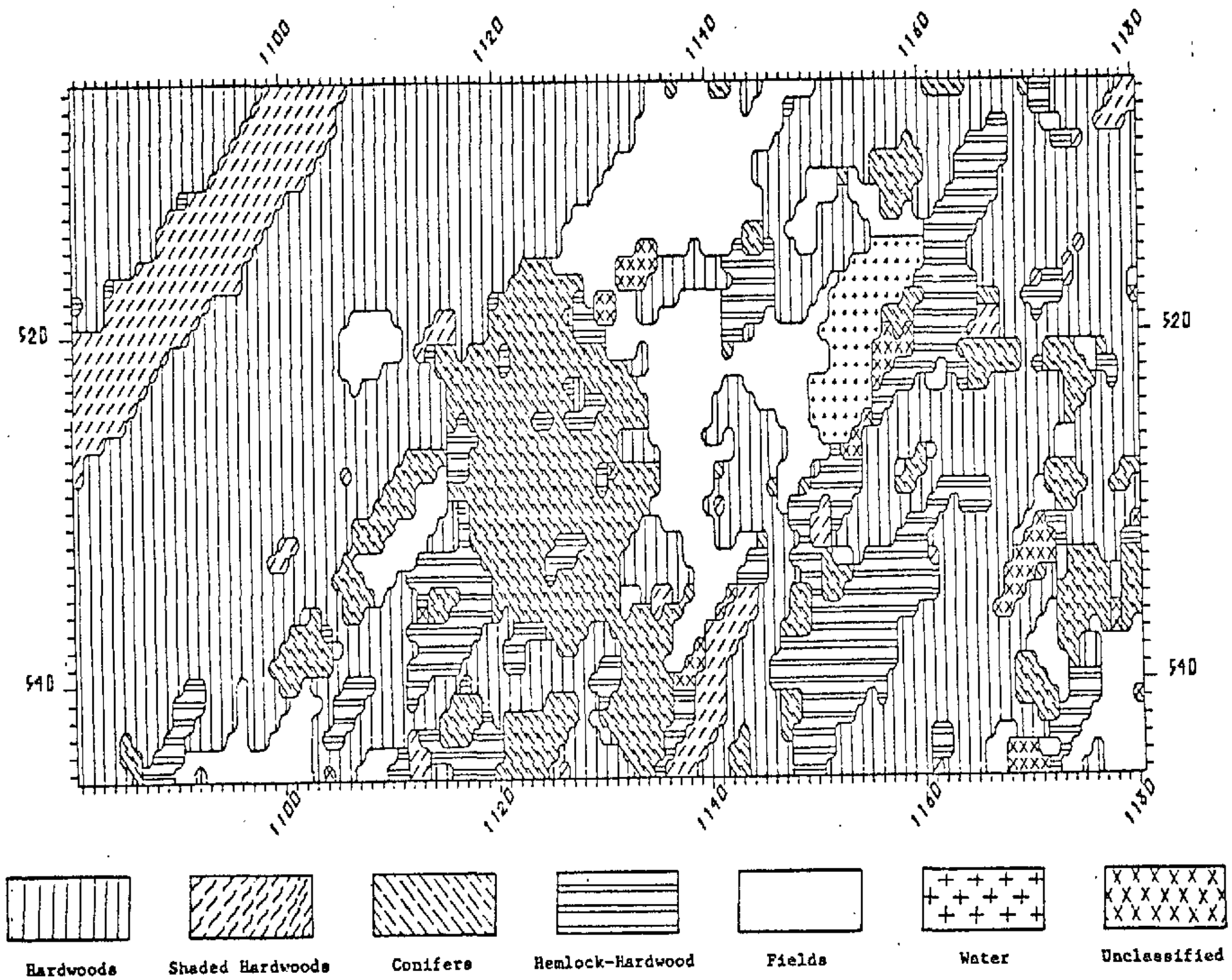

Figure 6 : LMAP printout of the ACLASS map shown in Figure .

separate category. However, the separation of spruce plantations from red pine plantations does not appear promising.

4. Discrimination between hardwood types in this scene does not appear very promising when using only winter and summer data, except where these types are characterized by association with evergreen species. The addition of spring and fall data may help. However, variation in hardwood type within the test area is not great.

5. Although major ridges do not occur within the experimental forest, their presence in the mapped scenes indicates potential problems in matching vegetation signatures in the shaded areas with signatures of the same vegetation type under open light. This is to be further investigated.

6. Clear-cut areas of more than 20 acres in size were easily detected by computer processing.

Conclusions

By computer processing of ERTS-1 tapes it is possible to identify and map major forest types. The precision of classification appears to be such that it could serve as a useful first stage of a multi-stage sampling scheme for forest inventory. Refinement of vegetation type identification is made possible by using merged data from different seasonal overpasses. Before this preliminary phase can be considered completed, however, further work is needed to explore additional refinements of classifications, to statistically analyze classification accuracy, and to develop procedures for classifying shaded vegetation.

ORSER-SSEL Technical Report 16-73
The Pennsylvania State University
May 1973